REMARKS

Further and favorable reconsideration is respectfully requested in view of the foregoing amendments and following remarks.

Telephone Conversations with Examiner

Initially, Applicants wish to thank the Examiner for his helpful comments and advice during the telephone conversations of August 10, 1007 and September 24, 2007. During these conversations, Applicants discussed proposed amendments to overcome the objection to the claims. The Examiner left a voice mail message on September 24, 2007, indicating that the amendments discussed below would be successful in overcoming the objection. The Examiner indicated that his Supervisor agreed with this position.

Consideration After Final Rejection

Although this amendment is presented after final rejection, the Examiner is respectfully requested to enter and consider the amendments, as they place the application in condition for allowance.

Claim Amendments

Claims 1 and 11 have been amended to recite that the inner surface of a vacuum member is mechanically polished in the presence of liquid medium, or a liquid medium and an oxidizing material, wherein the liquid medium includes no hydrogen atom. Mainly, the claims have been amended to delete the terms "optionally" and "may", in order to overcome the objection to the claims.

Claims 12, 13, 15 and 16 have been cancelled, without prejudice.

No new matter has been added to the application by these amendments.

Objection to the Claims

The objection to claims 1, 11, 12, 13, 15 and 16 has been overcome by the claim amendments. Specifically, the Examiner and his Supervisor indicated that the amendments to claims 1 and 11 would overcome the objection to these claims. Further, claims 12, 13, 15 and 16 have been cancelled, without prejudice.

Patentability Arguments

The patentability of the present invention over the disclosures of the references relied upon by the Examiner in rejecting the claims will be apparent upon consideration of the following remarks.

Rejection of Claims Under 35 U.S.C. § 103(a)

The rejection of claims 1, 3-13, 15 and 16 under 35 U.S.C. § 103(a) as being unpatentable over Higuchi et al. in view of Noguchi et al. and Kusano et al. is respectfully traversed.

The Examiner takes the position that Higuchi et al. and Noguchi et al. disclose the known process of surface treating an inner surface of a vacuum member by first mechanically polishing the vacuum member with a liquid medium containing hydrogen atoms, then subjecting the vacuum member to a chemical or electrochemical polishing process. The Examiner admits that neither reference teaches a liquid medium absent of any hydrogen atoms, wherein said liquid medium is a hydrocarbon in a molecule of which the hydrogen atom(s) are all substituted with fluorine atom(s).

The Examiner states that Kusano et al. teach a surface treatment method including an unsaturated hydrocarbon compound under ordinary pressure and ordinary temperature, wherein the hydrogen atoms are replaced with fluorine atoms. The Examiner admits, however, that the compound disclosed by Kusano et al. is a gaseous compound.

The Examiner takes the position that regardless of the medium, (gas, liquid, or even solid) since Kusano et al. teach a compound having the same effect or benefit as claimed by Applicant, which is to impart a smooth surface on the workpiece, the mediums could be interchangeable. Further, the Examiner asserts that it would have been obvious to modify the liquid medium used in the processes of Higuchi et al. and Noguchi et al. with a liquid medium formed as an unsaturated hydrocarbon compound under ordinary pressure and ordinary temperature, wherein the hydrogen atoms are replaced with fluorine atoms, based on Kusano et al.

A material of a vacuum member is subjected to various kinds of forming techniques such as cutting, bending, press working, bulging and electron beam welding. A strain, a damage, a surface wrinkle, embedding of foreign matter or the like, generated in the forming steps, cause various kinds of surface defective layers on, or in, an inner

surface of a vacuum member. This causes not only an adverse influence on a vacuum degree, but also increases surface resistance of a vacuum member. Therefore, it is common to subject a surface defective layer to mechanical polishing, electrochemical polishing or chemical polishing, such as those disclosed in Higuchi et al. and Noguchi et al. , to render the inner surface of the vacuum member smooth and clean. (Please see page 3, lines 4-17 of the specification.)

However, it was discovered that when mechanical polishing, chemical polishing and electrochemical polishing, as disclosed in Higuchi et al. and Noguchi et al., are applied to a vacuum member, hydrogen is occluded as a solid solution into the inner surface of the vacuum member. (Please see page 4, lines 5-8 of the specification.) When hydrogen is occluded as a solid solution into an inner surface of a vacuum member, the hydrogen is outdiffused and separated from the inner surface of the vacuum member when evacuation starts, and gradually released into a vacuum system, resulting in lowering an achieved vacuum degree. (Please see page 2, lines 9-14 of the specification.) Particularly, in a superconducting accelerating niobium cavity, niobium hydride is formed during cooling and a surface resistance increases to reduce acceleration performance. (Please see page 2, lines 22-26 of the specification.) Thus, a stable accelerating electric field and a high Q-value cannot be achieved in the superconducting accelerating niobium cavity. (Please see page 3, lines 18-24 of the specification.) Therefore, after the mechanical polishing, chemical polishing or electrolytic polishing, as disclosed in Higuchi et al. and Noguchi et al., vacuum annealing is required for dehydrogenation of the vacuum member, such as superconducting accelerating cavity. (Please see page 4, lines 5-10 and 15-19, and page 5, lines 11-12 of the specification.) However, vacuum annealing causes an increase in manufacturing steps and cost, reduction in mechanical strength of the vacuum member and recontamination on the inner surface thereof. (Please see page 11, lines 19-22 of the specification.)

The present inventors have found, for the first time, that when a vacuum member is formed and polished, occlusion of hydrogen as a solid solution into the vacuum member during mechanical polishing, chemical polishing or electrochemical polishing can be prevented by using a liquid medium including a saturated hydrocarbon in a molecule of which a hydrogen atom or hydrogen atoms are all substituted with a fluorine atom or fluorine atoms. According to the presently claimed invention, vacuum annealing

after mechanical polishing, chemical polishing or electrochemical polishing is not necessary.

Higuchi et al. disclose a process of surface treating an inner surface of a metallic hollow body by first mechanically polishing the hollow body with a polish assistant (water, a surfactant), then subjecting the hollow body to a chemical or electrochemical polishing process. (Please see paragraphs [0006] and [0018] of the reference.) However, Higuchi et al. do not disclose a hydrocarbon, particularly, a liquid medium including a saturated hydrocarbon in a molecule of which a hydrogen atom or hydrogen atoms are all substituted with a fluorine atom or fluorine atoms, as recited in Applicants' claims. Further, Higuchi et al. do not describe that a polish assistant is equivalent to, or may be replaced by, a saturated hydrocarbon in a molecule of which a hydrogen atom or hydrogen atoms are all substituted with a fluorine atom or fluorine atoms.

Noguchi et al. disclose a process of surface treating an inner surface of a metallic hollow body by polishing a metallic hollow body chemically or electrochemically with a polish liquid selected from fluoric acid, sulfuric acid, nitric acid, phosphoric acid, chromic anhydride, sodium hydroxide, sodium phosphate, or a mixture of two or more thereof. (Please see paragraphs [0006] and [0008] of the reference.)

However, Noguchi et al. do not disclose a hydrocarbon, particularly, a liquid medium including a saturated hydrocarbon in a molecule of which a hydrogen atom or hydrogen atoms are all substituted with a fluorine atom or fluorine atoms, as recited in Applicants' claims. Further, Noguchi et al. do not describe that a polish liquid is equivalent to, or may be replaced by, a saturated hydrocarbon in a molecule of which a hydrogen atom or hydrogen atoms are all substituted with a fluorine atom or fluorine atoms. Moreover, Noguchi et al. do not disclose mechanical polishing of a vacuum member.

Kusano et al. disclose a method for surface treating an article by subjecting the article, at its surface, to glow discharge plasma treatment under atmospheric pressure with a gas containing a fluorinated compound in the form of cyclic or unsaturated hydrocarbons having some or all of the hydrogen atoms thereof replaced by halogen groups including fluorine atoms. (Please see column 2, lines 44-52 and column 5, lines 11-16 of the reference.) However, Kusano et al. do not disclose mechanical polishing, as recited in Applicants' claims. Mechanical polishing is quite different from glow

discharge plasma treatment, as disclosed in Kusano et al. Moreover, Kusano et al. do not teach or suggest that glow discharge plasma treatment is equivalent to, or may be replaced by, mechanical polishing.

The problem to be solved by the presently claimed invention is to prevent occlusion of hydrogen as a solid solution into a vacuum member during mechanical polishing, chemical polishing or electrochemical polishing. The problem to be solved by Kusano et al. is lowering the surface energy of the article, imparting water repellency to the surface of the article and lowering a coefficient of friction with the article. Thus, the problem to be solved by the presently claimed invention is quite different from that of Kusano et al.

The Examiner states that Kusano et al. teach a compound having the same effect or benefit as claimed by the applicant, which is to impart a smooth surface on the workpiece. The Examiner further states that fluorinating a hydrocarbon is old and well known in the art, especially when a user desires to have a water repellent material, and that providing a gas, liquid or a solid to accomplish this concept is not novel because all yield an object with similar properties.

However, the effect of the presently claimed invention is to prevent occlusion of hydrogen as a solid solution into a vacuum member during mechanical polishing, chemical polishing or electrochemical polishing to give a high performance vacuum member at a low cost, which is used for, e.g. a superconducting accelerating cavity. Thus, the effect of the presently claimed invention is quite different from that disclosed in Kusano et al., namely lowering the surface energy of the article and imparting water repellency to the surface of the article. It would not have been obvious to one of ordinary skill in the art, from the teachings of Kusano et al., to use a liquid medium including a saturated hydrocarbon in a molecule of which a hydrogen atom or hydrogen atoms are all substituted with a fluorine atom or fluorine atoms to prevent occlusion of hydrogen as a solid solution into a vacuum member during mechanical polishing, chemical polishing or electrochemical polishing.

As discussed above, Higuchi et al. disclose a process of surface treating an inner surface of a metallic hollow body by first mechanically polishing the hollow body with a polish assistant (water, a surfactant), then subjecting the hollow body to a chemical or electrochemical polishing process. The problem to be solved by Higuchi et al. is to

extremely increase polishing removed amount and allow short time polishing by partially filling polishing media into inner space of a hollow body, rotating the hollow body itself, and revolving the hollow body around a revolution axis spaced from a rotation axis of the hollow body in the direction opposite to the rotation direction. (Please see the Patent Abstract of Japan of Higuchi et al.)

As discussed above, Noguchi et al. disclose a process of surface treating an inner surface of a metallic hollow body by polishing a metallic hollow body chemically or electrochemically with a polish liquid selected from fluoric acid, sulfuric acid, nitric acid, phosphoric acid, chromic anhydride, sodium hydroxide, sodium phosphate, or a mixture of two or more thereof. The problem to be solved by Noguchi et al. is to provide a method for polishing the inside surface of a metallic hollow body which is capable of preventing the unevenness of polishing, the leakage of a polish liquid and safely and cost effectively carrying out work and a novel polishing apparatus usable for the same. (Please see the Patent Abstract of Japan of Noguchi et al.)

As also discussed above, Kusano et al. disclose a method for surface treating an article by subjecting the article at its surface to glow discharge plasma treatment under atmospheric pressure with a gas containing a fluorinated compound in the form of cyclic or unsaturated hydrocarbons having some or all of the hydrogen atoms thereof replaced by halogen groups including fluorine atoms, thereby lowering the surface energy of the article, imparting water repellency to the surface of the article and lowering a coefficient of friction with the article. Namely, the problem to be solved by Kusano et al. is (a) lowering the surface energy of the article, (b) imparting water repellency to the surface of the article and (c) lowering a coefficient of friction with the article.

On the other hand, the problem to be solved by the presently claimed invention is to prevent occlusion of hydrogen as a solid solution into a vacuum member during mechanical polishing, chemical polishing or electrochemical polishing. This is neither disclosed nor suggested in Higuchi et al., Noguchi et al., Kusano et al., or the combination thereof. Therefore, there is no reason one would combine the teachings of Kusano et al. with Higuchi et al. or Noguchi et al., must less to prevent occlusion of hydrogen as a solid solution into a vacuum member during mechanical polishing, chemical polishing or electrochemical polishing.

The presently claimed invention has the effect of preventing the occlusion of hydrogen as a solid solution into a vacuum member during mechanical polishing, chemical polishing or electrochemical polishing by using a liquid medium including a saturated hydrocarbon in a molecule of which a hydrogen atom or hydrogen atoms are all substituted with a fluorine atom or fluorine atoms when the vacuum member is formed and polished. On the other hand, the effect of Higuchi et al. is to (a) increase an amount removed by polishing an inner surface of hollow object in a short time, (b) enhance an efficiency of polishing and (c) lessen unevenness of a polished surface. (Please see paragraph [0021] of Higuchi et al.) An effect of Noguchi et al. is to (a) prevent nonuniformity of a polished surface, (b) lose an effect of gas which occurs during polishing and (c) prevent generating of blemish. (Please see paragraphs [0029] and [0030] of Noguchi et al.) An effect of Kusano et al. is to (a) reduce a surface energy of a surface treated article, which will change little with the lapse of time, and (b) modify even materials, which are believed unamenable to glow discharge plasma treatment under atmospheric pressure with conventional fluorides, to be fully water repellent in a simple manner. (Please see column 5, lines 21-28 of Kusano et al.)

Therefore, the results of the presently claimed invention are unexpected from Higuchi et al. in view of Noguchi et al. and Kusano et al. The unexpected results of the presently claimed invention is neither disclosed nor suggested in Higuchi et al., Noguchi et al., Kusano et al., nor the combination thereof.

The unexpected results of the presently claimed invention are clearly disclosed in the present specification, as discussed below. Additionally, Applicants enclose herewith a Rule 132 Declaration detailing the Experiments and results.

In Test Example 1 (on pages 28-30 of the present specification), the effect of various liquid media on occlusion of hydrogen as a solid solution into a plate-shaped niobium in mechanical polishing (centrifugal barrel polishing disclosed in Higuchi et al.) was investigated. The result of Test Example 1 is as shown in the following table:

Liquid medium	Hydrogen concentration (detected values: ppm)	Polishing-off thickness (μm)
Water + Surfactant	79.1±5.0	About 30
None (dry)	10.9±0.8	About 0 to 5
Absolute propyl Alcohol	49.4±2.2	About 30
Hydrogen peroxide water (10%)	28.4±1.4	About 30
Fluorinert FC77	**4.6±0.8**	About 30

As is shown in the above table, when a vacuum member is mechanically polished with water and a surfactant as a polish assistant, as disclosed in Higuchi et al., hydrogen is occluded as a solid solution into the vacuum member (hydrogen concentration is 79.1±5.0 ppm). On the other hand, occlusion of hydrogen as a solid solution into the vacuum member is dramatically suppressed by mechanically polishing the niobium sample with a liquid medium including a saturated hydrocarbon in a molecule of which a hydrogen atom or hydrogen atoms are all substituted with a fluorine atom or fluorine atoms, such as Fluorinert FC77, as in the presently claimed invention (hydrogen concentration is 4.6±0.8 ppm). Incidentally, an average polishing-off thickness in the range from about 0 to 5 μm in a case of a dry polishing (without a liquid medium) shows almost no polishing-off on the sample in this method.

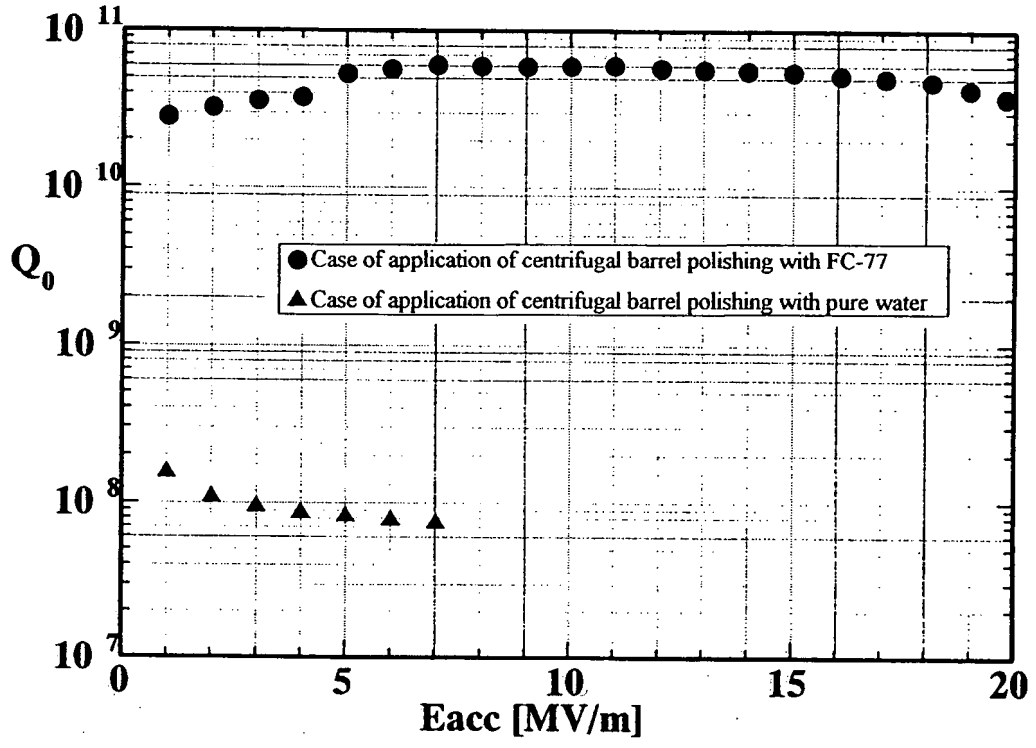
In Test Example 2 (on pages 30-31 of the specification), an effect of a liquid medium containing an oxidizing material such as ozone on occlusion of hydrogen as a solid solution into a plate-shaped niobium in mechanical polishing (centrifugal barrel polishing) was investigated. The result of Test Example 2 is as shown in the following table:

Liquid medium	Hydrogen concentration (ppm)	Polishing-off thickness (μm)
FC-77 + ozone	2.67±0.5	about 30
FC-77 alone	4.60±0.8	about 30

As shown in the above table, the occlusion of hydrogen as a solid solution into the vacuum member is further suppressed by mechanically polishing the niobium sample with Fluorinert FC77 and an oxidizing material such as ozone.

In Example 1 of the present specification, a niobium superconducting accelerating cavity surface-treated by the presently claimed process was manufactured. A 1300 MHz single cell cavity (a total cavity length of 370 mm, the maximum cavity diameter of 210 mm, a beam pipe diameter of 80 mm and a thickness of 2.5 mm) was subjected to mechanical polishing (centrifugal barrel polishing). Fluorinert FC-77 was employed as a liquid medium for mechanical polishing. After cleaning with pure water, the cavity was subjected to chemical polishing with a solution (89 w/v % phosphoric acid : 67 w/v % nitric acid : 40 w/v % hydrofluoric acid = 1 vol : 1 vol : 1 vol) (a target of polishing-off was 50 μm). As Comparative Example 1, another single cell cavity was subjected to centrifugal barrel polishing with water only as a liquid medium and then chemically polishing in conformity with Example 1.

Total polishing-off thickness values of the cavities of Example 1 and Comparative Example 1 thus obtained were measured with the result of an average thickness of about 80 um. Acceleration performances (Q-values and accelerating electric fields [Eacc: MV/m]) of the cavities are shown in the Figure below.



Reduction in Q-value was observed with a rise in an accelerating electric field in the cavity of Comparative Example 1 obtained in a procedure in which after centrifugal barrel polishing with pure water, chemical polishing was applied. No reduction in Q-value in the cavity of Example 1 was observed, even with a rise in accelerating electric field. Therefore, it is clear that the accelerating cavity prepared in Example 1 has by far higher acceleration performance as compared with that in Comparative Example 1.

For these reasons, the invention of claims 1 and 3-11 (claims 12, 13, 15 and 16 were cancelled) is clearly patentable over the cited combination of references.

Conclusion

Therefore, in view of the foregoing amendments and remarks, it is submitted that the ground of objection and rejection set forth by the Examiner have been overcome, and that the application is in condition for allowance. Such allowance is solicited.

If, after reviewing this Amendment, the Examiner feels there are any issues remaining which must be resolved before the application can be passed to issue, the Examiner is respectfully requested to contact the undersigned by telephone in order to resolve such issues.

Respectfully submitted,

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